

**TEATCUP LINER AND FAMILY**

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## TEATCUP LINER AND FAMILY

### CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of U.S. Patent Application Serial  
5 No. 10/071,332, filed February 8, 2002.

### BACKGROUND AND SUMMARY

#### Parent Application

The invention of the noted parent application relates to teatcup liners for use  
10 in a teatcup assembly for milking a mammal.

As known in the prior art, a plurality of teatcups are connected to respective  
teats suspending from the udder of a mammal such as a cow. Each teatcup  
assembly has a teatcup liner or inflation around a respective teat and defining a  
milk flow passage within the liner below the teat, and a pulsation chamber outside  
15 the liner between the liner and the teatcup shell, for example U.S. Patents  
4,269,143, 4,530,307, 5,178,095, 5,218,924, 6,055,931, all incorporated herein by  
reference. The system has a milking cycle with an on portion and an off portion.  
Milk flows from the teat towards a milking claw during the on portion, and then to  
a storage vessel. During the off portion, the liner is collapsed around the teat, to  
20 aid in the circulation of body fluids. Vacuum is continuously applied to the milk  
flow passage within the liner. Vacuum is alternately and cyclically applied to the  
pulsation chamber between the liner and the teatcup shell, to open and close the  
liner, all as is known.

The parent invention provides a liner series or family enabling the dairyman  
25 selectivity in choosing between the trade-off of liner slip versus milk harvest and  
milking speed. During continuing development efforts, various relationships have  
been discovered between various liner parameters, and in accordance therewith, a  
liner series has been developed having at least one and preferably a plurality of  
parameters which vary liner to liner in optimized manner to afford the noted  
30 selectivity.

In a further aspect of the parent invention, a particularly cost effective manufacturing method is provided for producing the liner series.

#### Present Invention

5 The present invention evolved during continuing development efforts related to the above-noted parent invention. Further options are provided enabling the dairyman selectivity in choosing higher milking speed or less liner slip. Further improvements in individual liner construction have also been developed.

### BRIEF DESCRIPTION OF THE DRAWINGS

#### 10 Parent Application

Fig. 1 is taken from U.S. Patent 6,055,931 and is a side view partially in section of a teatcup assembly including a teatcup liner for milking a mammal.

Fig. 2 is an isometric view of a teatcup liner.

Fig. 3 shows a teatcup liner series in accordance with the parent invention.

15 Fig. 4 is a graphical plot of a selected parameter which varies in accordance with the parent invention.

Fig. 5 is a graphical plot of the variance of a pair of parameters versus each other in accordance with the parent invention.

20 Fig. 6 is a graphical plot of the variance of another pair of parameters versus each other in accordance with the parent invention.

Fig. 7 is a graphical plot of the variance of another pair of parameters versus each other in accordance with the parent invention.

Fig. 8 is a graphical plot of the variance of another pair of parameters versus each other in accordance with the parent invention.

25 Fig. 9 is a graphical plot of the variance of another pair of parameters versus each other in accordance with the parent invention.

Fig. 10 is a cross-sectional view of a liner.

Fig. 11 is like Fig. 10 and shows another embodiment.

Fig. 12 is like Fig. 10 and shows another embodiment.

30 Fig. 13 is like Fig. 10 and shows another embodiment.

Fig. 14 is like Fig. 10 and shows another embodiment.

Fig. 15 is like Fig. 10 and shows another embodiment.

Fig. 16 is like Fig. 3 and illustrates a manufacturing method in accordance with the parent invention.

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#### Present Invention

Fig. 17 is a side sectional view similar to Fig. 3 and illustrating the first and last liners in the series in accordance with the present invention.

Fig. 18 is like Fig. 17 and shows another embodiment.

Fig. 19 is a sectional view taken along line 19-19 of Fig. 18.

10 Fig. 20 is a sectional view taken along line 20-20 of Fig. 18.

Fig. 21 is like Fig. 18 and shows another embodiment.

### DETAILED DESCRIPTION OF THE INVENTION

#### Parent Application

15 Fig. 1 shows a teatcup assembly 18 for milking a mammal 20 such as a cow. Teat 22 suspending from udder 24 of the mammal extends into the liner. Teatcup shell 26 is typically a metal, or plastic, member defining an annular pulsation chamber 28 around liner 16 between the liner and the teatcup shell and having a pulsation port 30 for connection to a pulsator valve, as is known. Liner 16 is  
20 typically rubber or other flexible material. The lower end of milk tube portion 14 of the liner is connection to a claw, for example U.S. Patents 4,537,152 and 5,291,853, incorporated herein by reference, which in turn supplies milk to a storage vessel. As noted above, vacuum is continuously applied to milk passage 32 within the liner through milk tube portion 14, and vacuum is alternately and cyclically applied to  
25 pulsation chamber 28 through port 30, to open and close liner 16 below teat 22, all as is known and for which further reference may be had to the above noted incorporated patents. An air vent plug 10 may be inserted through the wall 12 of the milk tube portion 14 of the teat liner, as is known, for example above noted incorporated U.S. Patent 6,055,931. For further background, a teatcup liner is  
30 illustrated in isometric view at 34 in Fig. 2.

Fig. 3 illustrates a teatcup liner series in accordance with the parent invention including in combination a plurality of related teatcup liners comprising n liners  $L_1$  through  $L_n$ , for example as shown at the nine liners  $L_1$  through  $L_9$ . Each liner such as 40 has an upper mouthpiece 42, an intermediate barrel 44 defined by a barrel wall 46, and a lower connecting tube 48. The barrel extends along an axial direction 50 for receiving teat 22 inserted axially thereinto through mouthpiece 42. The mouthpiece has an upper lip 52 having an aperture 54 therethrough for receiving teat 22. Lip 52 has an axial thickness A measured parallel to axial direction 50. Barrel wall 46 has axially spaced upper and lower portions 56 and 58. Upper portion 56 of barrel wall 46 has a transverse thickness B measured transversely to axial direction 50. Lower portion 58 of barrel wall 46 has a transverse thickness C measured transversely to axial direction 50. Upper portion 56 of barrel wall 46 has inner surfaces 60 defining a hollow interior with an upper transverse span D thereacross taken transversely to axial direction 50. Lower portion 58 of barrel wall 46 has inner surfaces 62 defining a hollow interior with a lower transverse span E thereacross taken transversely to axial direction 50. Lip aperture 54 has a transverse dimension taken transversely to axial direction 50 and defining a mouthpiece bore F. Mouthpiece 42 has a cavity 64 between lip 52 and barrel 44. Cavity 64 has a transverse dimension taken transversely to axial direction 50 and defining a cavity bore G. Cavity 64 has a volume H.

In one preferred embodiment, the noted parameters A through H are varied liner to liner from  $L_1$  through  $L_9$  as indicated in the table below, and as set forth in Fig. 3. The table below gives dimensions for A through G in millimeters (mm). For example, the axial thickness A of lip 52 varies from 2.0mm for liner  $L_1$  to 3.6mm for liner  $L_9$ . The table gives dimensions in cubic inches ( $\text{in}^3$ ) for H.

TABLE

LINER									
	$L_1$	$L_2$	$L_3$	$L_4$	$L_5$	$L_6$	$L_7$	$L_8$	$L_9$
A(mm)	2.0	2.2	2.4	2.6	2.8	3	3.2	3.4	3.6
B(mm)	3.2	3.1	3.0	2.9	2.8	2.7	2.6	2.5	2.4

LINER									
	L <sub>1</sub>	L <sub>2</sub>	L <sub>3</sub>	L <sub>4</sub>	L <sub>5</sub>	L <sub>6</sub>	L <sub>7</sub>	L <sub>8</sub>	L <sub>9</sub>
C(mm)	2.9	2.8	2.7	2.6	2.5	2.4	2.3	2.2	2.1
D(mm)	20.2	20.4	20.6	20.8	21	21.2	21.4	21.6	21.8
E(mm)	18.9	19.1	19.3	19.5	19.7	19.9	20.1	20.3	20.5
F(mm)	20.4	20.3	20.2	20.1	20.0	19.9	19.8	19.7	19.6
G(mm)	52.95	52.65	52.25	51.85	51.45	51.05	50.65	50.25	49.85
H(in <sup>3</sup> )	1.368	1.353	1.336	1.318	1.301	1.283	1.265	1.248	1.230
A-B(mm)	-1.2	-0.9	-0.6	-0.3	0	0.3	0.6	0.9	1.2

The liner series is characterized by the following relationships, as illustrated in the table and Fig. 3: axial thickness A of lip 52 continually increases from L<sub>1</sub> through L<sub>n</sub>, preferably linearly; transverse thickness of barrel wall 46, including both B and C, continually decreases from L<sub>1</sub> through L<sub>n</sub>, preferably linearly; the transverse span across the hollow interior, including both D and E, continually increases from L<sub>1</sub> through L<sub>n</sub>, preferably linearly; mouthpiece bore F continually decreases from L<sub>1</sub> through L<sub>n</sub>, preferably linearly; cavity bore G continually decreases from L<sub>1</sub> through L<sub>n</sub>, preferably linearly; cavity volume H continually decreases from L<sub>1</sub> through L<sub>n</sub>.

In the preferred embodiment, B is always greater than C, and D is always greater than E, such that both the barrel wall thickness and the noted transverse span are tapered. In alternate embodiments, the barrel wall thickness and/or the transverse span may be untapered, i.e. straight.

Further, in the preferred embodiment, the parameter A-B, i.e. the difference between A and B, varies as illustrated in the table, namely such difference continually increases from L<sub>1</sub> through L<sub>9</sub>, preferably linearly, as further illustrated in Fig. 4.

Further, in the preferred embodiment, in a plot, Fig. 5, of transverse thickness B of barrel wall 46 versus axial thickness A of lip 52 for liners L<sub>1</sub>

through  $L_9$ , B decreases as A increases. Further preferably, B decreases linearly with respect to A.

Further in the preferred embodiment, in a plot, Fig. 6, of transverse span D versus axial thickness A of lip 52 for  $L_1$  through  $L_9$ , D decreases as A increases.

5 Further preferably, D decreases linearly with respect to A. In another preferred embodiment, D increases as A increases, the latter being preferred when using the manufacturing method described hereinbelow.

Further in the preferred embodiment, in a plot, Fig. 7, of axial thickness A of lip 52 versus mouthpiece bore F for  $L_1$  through  $L_9$ , axial thickness A decreases  
10 as mouthpiece bore F increases. Further preferably, A decreases linearly with respect to F.

Further in the preferred embodiment, in a plot, Fig. 8, of axial thickness A of lip 52 versus cavity bore G for  $L_1$  through  $L_9$ , axial thickness A decreases as cavity bore G increases. Further preferably, A decreases linearly with respect to G.

15 Further in the preferred embodiment, in a plot, Fig. 9, of axial thickness A of lip 52 versus cavity volume H for  $L_1$  through  $L_9$ , axial thickness A decreases as cavity volume H increases. Further preferably, A decreases linearly with respect to H.

The disclosed combination enables selection of desired milking  
20 characteristics. Liner  $L_1$  provides the highest milk harvest and highest milk speed, but also the greatest liner slip. Liner  $L_9$  provides the lowest liner slip and also the lowest milk harvest and milking speed. The dairyman can choose the right balance and trade-off for his particular needs. As he moves left to right in Fig. 3, liner slip reduces as does milk harvest and milking speed. As he moves right to left in Fig.  
25 3, liner slip increases as does milk harvest and milking speed.

The liner is preferably round as shown at 66 in Fig. 10. The liner may additionally include a plurality of ribs such as 68, Figs. 11 and 2, extending axially along the barrel. The ribs may be external as shown, and/or internal. The liner may be triangular as shown at 70 in Fig. 12. The liner may be square as shown at

72 in Fig. 13. The liner may be oval as shown at 74 in Fig. 14. The liner may be fluted as shown at 76 in Fig. 15.

The various combinations of parameters providing the noted selectivity of milking characteristics are set forth in the claims. Deflection of lip 52 is varied by parameter A, and may additionally or alternately be varied by varying the shore hardness of the lip material. Liner barrel tension is varied by varying the noted wall thickness B and C, and may alternately or additionally be varied by the addition of the noted ribs and/or changing the cross-section of individual ribs and/or changing liner material and/or changing barrel length.

There is further provided a simple and particularly cost effective and economical manufacturing method for making the teatcup liner series. The method involves: forming a first of the liners  $L_1$  in a mold 80, Fig. 16, having a first removable core  $C_1$  inserted therein, the mold forming the outer profile surface 82 of liner  $L_1$ , the core  $C_1$  forming the inner profile surface 84 of liner  $L_1$ ; forming a second of the liners  $L_2$  in the same mold 80 having a second removable core  $C_2$  inserted therein, the mold 80 forming the outer profile surface 86 of liner  $L_2$ , the core  $C_2$  forming the inner profile surface 88 of liner  $L_2$ ; forming the remainder of the liners through  $L_n$ , e.g.  $L_3$  through  $L_9$ , in the same mold 80 having respective removable cores through  $C_n$ , e.g.  $C_3$  through  $C_9$ , inserted therein, the mold 80 forming the outer profile surface of the liners through  $L_n$ , the cores through  $C_n$  forming the inner profile surfaces of the liners through  $L_n$ , e.g. cores  $C_3$  through  $C_9$  form the inner profile surfaces for liners  $L_3$  through  $L_9$ , respectively. The same mold 80 is used for each of the liners  $L_1$  through  $L_9$ . The outer profile surface is the same for each of liners  $L_1$  through  $L_9$ . Different cores  $C_1$  through  $C_9$  are used for liners  $L_1$  through  $L_9$ . The inner profile surface is different from liner to liner according to  $C_1$  through  $C_9$ . Any or all or some combination of the noted parameters A-H are varied liner to liner according to  $C_1$  through  $C_9$ . The cores change a selected dimensional parameter or parameters. This is particularly desirable from a manufacturing standpoint because of the savings in tooling cost by using a single mold to produce the liner series, rather than multiple molds, i.e. one



for each liner. Instead, different cores are used to provide the variance liner to liner in the series. Cores are significantly less expensive than a mold.

#### Present Invention

Fig. 17 shows the first and last of a teatcup liner series 100 including in combination a family of related teatcup liners such as 102, 104, etc. Each liner has an upper mouthpiece 106, a barrel 108 depending downwardly from the upper mouthpiece, and a lower connecting tube 110 depending downwardly from the barrel. The barrel extends axially along an axis 112 for receiving a teat 22, Fig. 1, inserted axially therein through mouthpiece 106. The teatcup liner series includes  $n$  liners  $L_1$  through  $L_n$ , e.g.  $L_1$  through  $L_9$ , as above. The material of at least one of the mouthpiece and the barrel progressively varies in hardness from  $L_1$  to  $L_9$ . In this embodiment, all of the liners in the liner series 100, namely  $L_1$  to  $L_9$  in Fig. 17, have the same dimensions, including barrel wall thickness at the top of the barrel, dimension B above (e.g. 3.30mm), liner ID (internal diameter) bore or transverse span, dimension D above (e.g. 20mm), and mouthpiece lip thickness, dimension A above (e.g. 3.80mm), etc. In Fig. 17, liners  $L_1$  through  $L_n$  are dimensionally the same. The difference between liners  $L_1$  through  $L_n$  in Fig. 17 is the hardness of the rubber compound that is used to make different parts of the liners. The material of at least one of the mouthpiece 106 and the barrel 108 progressively varies in hardness from  $L_1$  to  $L_9$ .

The material of mouthpiece 106 progressively increases in hardness from  $L_1$  to  $L_9$ . In one embodiment, the mouthpiece of liner  $L_1$  is a soft rubber compound of 36 Shore hardness, and the mouthpiece of liner  $L_9$  is a harder rubber compound of 44 Shore hardness. The opposite is true for barrel 108. The material of the barrel 108 progressively decreases in hardness from  $L_1$  to  $L_9$ . In one embodiment, barrel 108 of liner  $L_1$  is a harder rubber compound, namely 44 Shore hardness, and the barrel of liner  $L_9$  is a softer rubber compound, namely 36 Shore hardness. Further in the preferred embodiment, the liners  $L_1$  through  $L_9$  at respective mouthpieces 106 and barrels 108 change in their hardness by one Shore hardness liner to liner. The material of mouthpiece 106 progressively increases in hardness from  $L_1$  to  $L_n$ .

The material of barrel 108 progressively decreases in hardness from  $L_1$  to  $L_n$ . It is preferred that in combination the material of both mouthpiece 106 and barrel 108 progressively vary from  $L_1$  to  $L_n$  and further preferably that the material of mouthpiece 106 and the material of barrel 108 vary inversely relative to each other from  $L_1$  to  $L_n$ . It is further preferred that lower connecting tube 110 remain substantially the same hardness from  $L_1$  to  $L_9$  preferably a harder rubber compound, preferably 44 Shore hardness.

Fig. 18 shows another embodiment including a teatcup liner series 120 including in combination a family of related teatcup liners such as 122 through 124, each liner having an upper mouthpiece 126, a barrel 128 depending downwardly from the upper mouthpiece, and a lower connecting tube 130 depending downwardly from the barrel. The barrel extends axially along an axis 132 for receiving a teat 22, Fig. 1, inserted axially therein through mouthpiece 126. The teatcup liner series includes  $n$  liners  $L_1$  through  $L_n$ , such as  $L_1$  through  $L_9$ . A plurality of grooves 134 extend along at least one of mouthpiece 126 and barrel 128. The grooves have a groove width 136, Fig. 18, measured transversely to axis 132 and arcuately partially circumferentially around the hollow interior of the liner. The grooves also have a groove width 138, Fig. 20, measured transversely to axis 132 and taken radially relative thereto. The groove widths 136, 138 progressively vary from  $L_1$  to  $L_9$ .

In one embodiment, the noted grooves extend along the mouthpiece as shown at 140, and the noted groove width progressively decreases in the mouthpiece from  $L_1$  to  $L_9$ , as shown at respective groove widths 142 and 144. Mouthpiece 126 has an upper lip 146 having an aperture 148 therethrough for receiving teat 22. Mouthpiece 126 has a cavity 150 between lip 146 and barrel 128. The noted grooves extend along cavity 150, and the noted groove width in the cavity progressively decreases from  $L_1$  to  $L_9$ , as shown by the decrease from groove width 142 to groove width 144. The noted grooves 134 also extend axially along barrel 128, as shown at 152, and the groove width along the barrel progressively increases from  $L_1$  to  $L_9$ , as shown at the increase in groove width

from 154 to 156. It is preferred that both the lateral circumferential groove width increase from  $L_1$  to  $L_9$ , and also the radial groove width increase from  $L_1$  to  $L_9$ , as shown at the increase from 158 to 160, Figs. 19, 20.

In the preferred embodiment, grooves 134 extend along both the mouthpiece 126 and the barrel 128. The grooves have upper sections 162 in the mouthpiece, and have lower sections 164 in the barrel. It is preferred that in combination the groove width of the upper sections 162 of the grooves progressively decreases from  $L_1$  to  $L_9$ , and the groove width of the lower sections 164 of the grooves progressively increases from  $L_1$  to  $L_9$ .

Further in accordance with the invention, the noted upper sections, e.g. 140, 162 of the grooves have a different groove width than the lower sections e.g. 152, 164 of the grooves. For liner 122,  $L_1$  in Fig. 18, upper sections 140 of the grooves have a larger groove width 142 than the groove width 154 of lower sections 152 of the grooves. For liner 124,  $L_9$  in Fig. 18, the upper sections of the grooves have a smaller groove width 144 than the groove width 156 of the lower sections of the grooves. The grooves extend upwardly along barrel 128 and then along cavity 150 and lip 146 to aperture 148. Groove transition sections 158,  $L_1$ , 160,  $L_9$ , transition the grooves to the noted different groove width.

Liner  $L_1$  in Fig. 17 and liner  $L_1$  in Fig. 18 provide faster milking. Liner  $L_9$  in Fig. 17 and liner  $L_9$  in Fig. 18 provide less slip.

Fig. 21 shows another embodiment including a teatcup liner series 170 including in combination a family of related teatcup liners such as 172 through 174, each liner having an upper mouth piece 176, a barrel 178 depending downwardly from the upper mouthpiece, and a lower connecting tube 180 depending downwardly from the barrel. The barrel extends axially along an axis 182 for receiving a teat 22, Fig. 1, inserted axially therein through mouthpiece 176, namely through aperture 184 of upper lip 186. The teatcup liner series includes N liners  $L_1$  through  $L_n$ , such as  $L_1$  through  $L_9$ . A plurality of grooves 188 extend along at least one of mouthpiece 176 and barrel 178. The grooves have a groove width 190 progressively varying from  $L_1$  to  $L_9$ . Groove width 190 extends

axially. The grooves also have a groove width 192 progressively varying from  $L_1$  to  $L_9$ . Groove width 192 extends transversely to axis 182, namely radially relative thereto. Grooves 188 extend transversely to axis 182, namely arcuately circumferentially around the hollow interior of the liner. Mouthpiece 176 has a cavity 194 between lip 186 and barrel 178. The grooves may extend along the barrel as shown at 188 and there may also be grooves as shown at 196 extending along and around cavity 194.

In one embodiment, the axial groove width 190 of grooves 188 extending around the hollow interior of barrel 178 progressively increases from  $L_1$  to  $L_9$ , as shown by the increase from axial groove width 198 to axial groove width 200. Radial groove width 192 of grooves 188 also progressively increases from  $L_1$  to  $L_9$ , as shown by the increase from radial groove width 202 to radial groove width 204. The axial and/or radial groove widths of grooves 196 in cavity 194 of mouthpiece 176 may also be varied. In one embodiment, the groove widths of grooves 196 increase from  $L_1$  to  $L_n$  and/or groove structure is otherwise modified or varied to provide a stiffer lip for liner  $L_9$  than liner  $L_1$  to provide less liner slip for liner  $L_9$ . For example, the number or size of grooves such as 206, 208 may be varied to remove more or less material, or to control deflection as in co-pending U.S. Patent Application Serial No. 10/359,848, filed February 7, 2003, incorporated herein by reference. Each of the vertical axial groove structure of Fig. 18 and the horizontal lateral groove structure of 21 removes material from the barrel wall in a controlled progressive manner to vary milking characteristics as noted, e.g. providing faster milking as one moves right to left in Figs. 21 and 18 from liner  $L_9$  to liner  $L_1$ .

It is recognized that various equivalents, alternatives and modifications are possible within the scope of the appended claims.